

Basewide Energy Systems Plan

Executive Summary

Final Report

Fort Knox, Kentucky

19971023 141

March 1983

Prepared For
MOBILE DISTRICT CORPS OF ENGINEERS
MOBILE, ALABAMA
CONTRACT DACA01-77-C-0094

Prepared By
BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

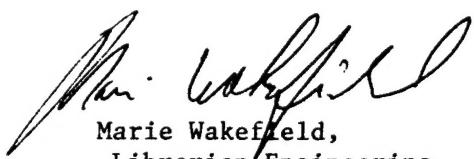


DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO
ATTENTION OF: TR-I Library

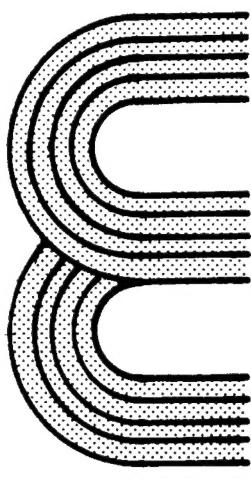
17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited.
Distribution A. Approved for public release.



A handwritten signature in black ink, appearing to read "Marie Wakefield".

Marie Wakefield,
Librarian Engineering



Basewide Energy Systems Plan

Executive Summary

Final Report

Fort Knox, Kentucky

March 1983

Prepared For
MOBILE DISTRICT CORPS OF ENGINEERS
MOBILE, ALABAMA
CONTRACT DACA01-77-C-0094

Prepared By
BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

EXECUTIVE SUMMARY - INCREMENTS A, B, C, D, AND E

This is a summary of the results of the Basewide Energy Systems Plan for Fort Knox, Kentucky. This plan includes analyses and recommendations of energy conservation projects for reduction of the installation's present energy consumption. The savings figures presented in this summary can only be realized after all projects have been implemented. Black & Veatch has developed projects that would meet the funding requirements for the energy conservation program. Furthermore, the recommended projects provide partial compliance with the energy conservation requirement for the installation as outlined in the Army Facilities Energy Plan. This summary presents data on the following:

- Energy use model
- Existing energy consumption
- Source energy reductions due to energy conservation techniques for buildings and their systems
- Application of solar energy to reduce fossil fuel consumption
- Savings utilizing central energy monitoring and control systems (EMCS)
- Use of solid waste as an alternate energy source
- Analysis of Total Energy/Selective Energy (TE/SE) systems

Tables 1 and 2 in the Appendix present information pertaining to the physical descriptions and energy consumption of 49 typical buildings used to verify historical energy consumption in the development of the basewide energy use model. This model was then utilized as the

foundation for energy conservation project analyses and recommendations. Table 3 in the Appendix summarizes the daily personnel occupancy for each typical building. Tables 1, 2, and 3 also provide information which was used to estimate source energy consumption for similar buildings within the designated groupings.

Table 4 in the Appendix indicates the annual source energy consumed by each of the significant building groups used in our basewide energy use model. The estimated annual source energy consumption for all building groups calculated by the energy use model for base year 1975 was 4,513,004 mega-Btu per year. The energy use model was within 7 percent of the historical source energy consumption for FY 1975 shown below.

Historical Source Energy
Consumption in Btu x 10⁶

FY 75

Electricity	1,496,934
Natural Gas	2,255,523
Propane Gas	1,098
Fuel Oil No. 2	429,974
Coal	<u>25,391</u>
TOTAL	4,208,920

Figure 1 illustrates a percentage breakdown of the annual source energy consumption by building group from Table 4.

The total estimated source energy savings due to implementation of all feasible energy conservation projects developed within the scope of this study is 782,633 mega-Btu per year. These projects consisted of

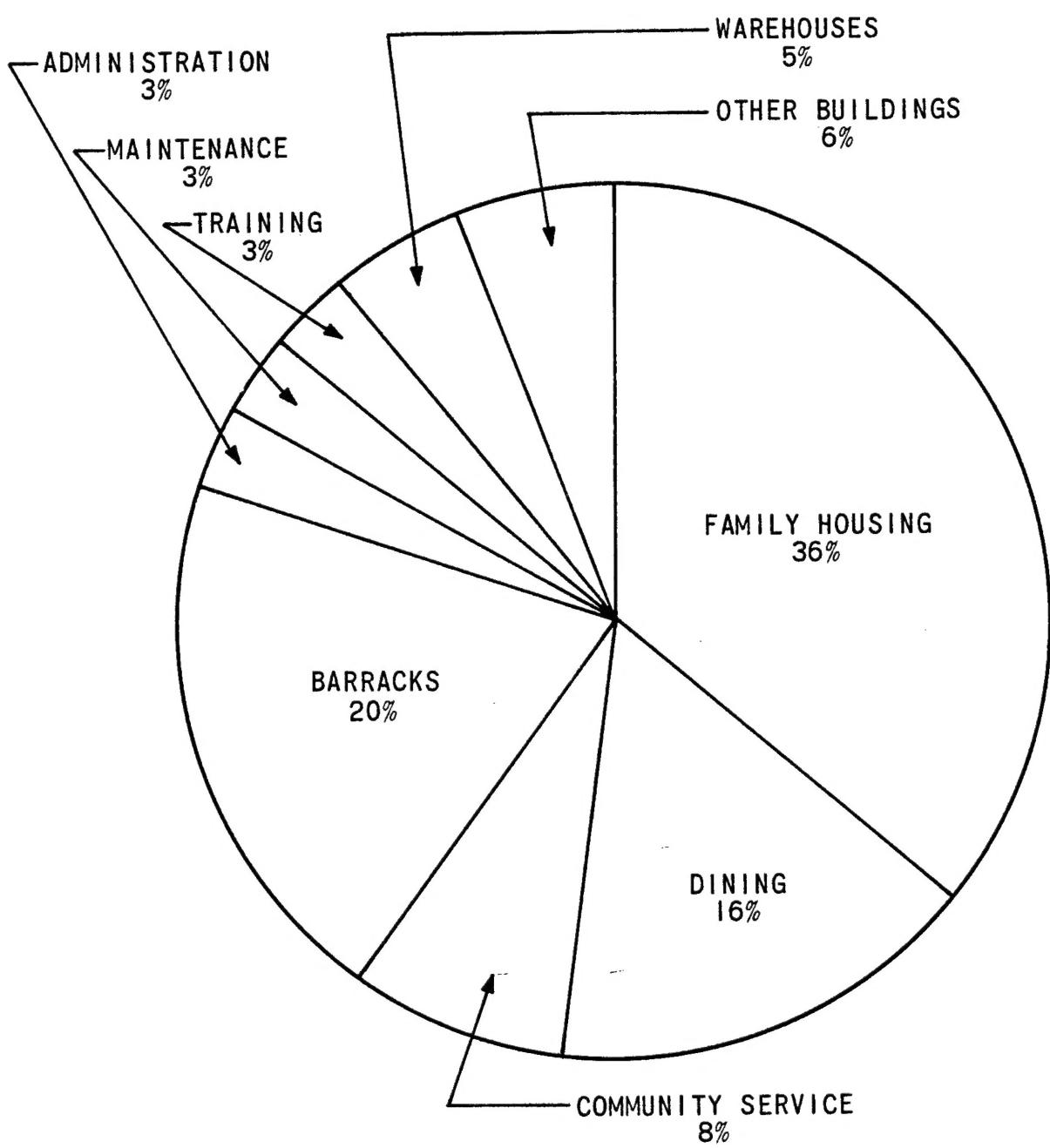


FIGURE 1
FORT KNOX
BASEWIDE SOURCE ENERGY CONSUMPTION
(BASE YEAR 1975)

various architectural improvements, and mechanical and electrical system modifications and are summarized in Tables 5 and 6 in the Appendix.

Table 5 lists the project number, percent of basewide reduction, and the source energy savings. Figure 2 illustrates the combined effect of the recommended energy saving improvements, as compared to the FY 1975 source energy consumption. The estimates indicate a savings of approximately 19 percent over the base year FY 75. Further explanation of the historical energy consumption, basewide energy model, and energy conservation analysis, can be found in the Energy Use Survey in Volume I. Figure 3 illustrates the allocation of the energy conservation projects for significant building groups.

Table 6 was developed to give a prioritized schedule, in order of fiscal year, for implementing the recommended energy conservation projects.

Utilizing solar energy, a renewable energy source, to reduce dependence on nonrenewable energy sources at Fort Knox revealed the concepts investigated would be economically impracticable. Seven concepts were evaluated and are presented in the Solar Energy Applications and Evaluations in Volume I.

The Energy Monitoring and Control Systems (EMCS) study includes recommendations for an extension of the existing system and the utilization of an FM control system. The study shows expanding the existing system would result in a savings of 64,833 mega-Btu per year, and the FM control system would save 50,412 mega-Btu per year. An expansion of the EMCS system is scheduled for FY 85.

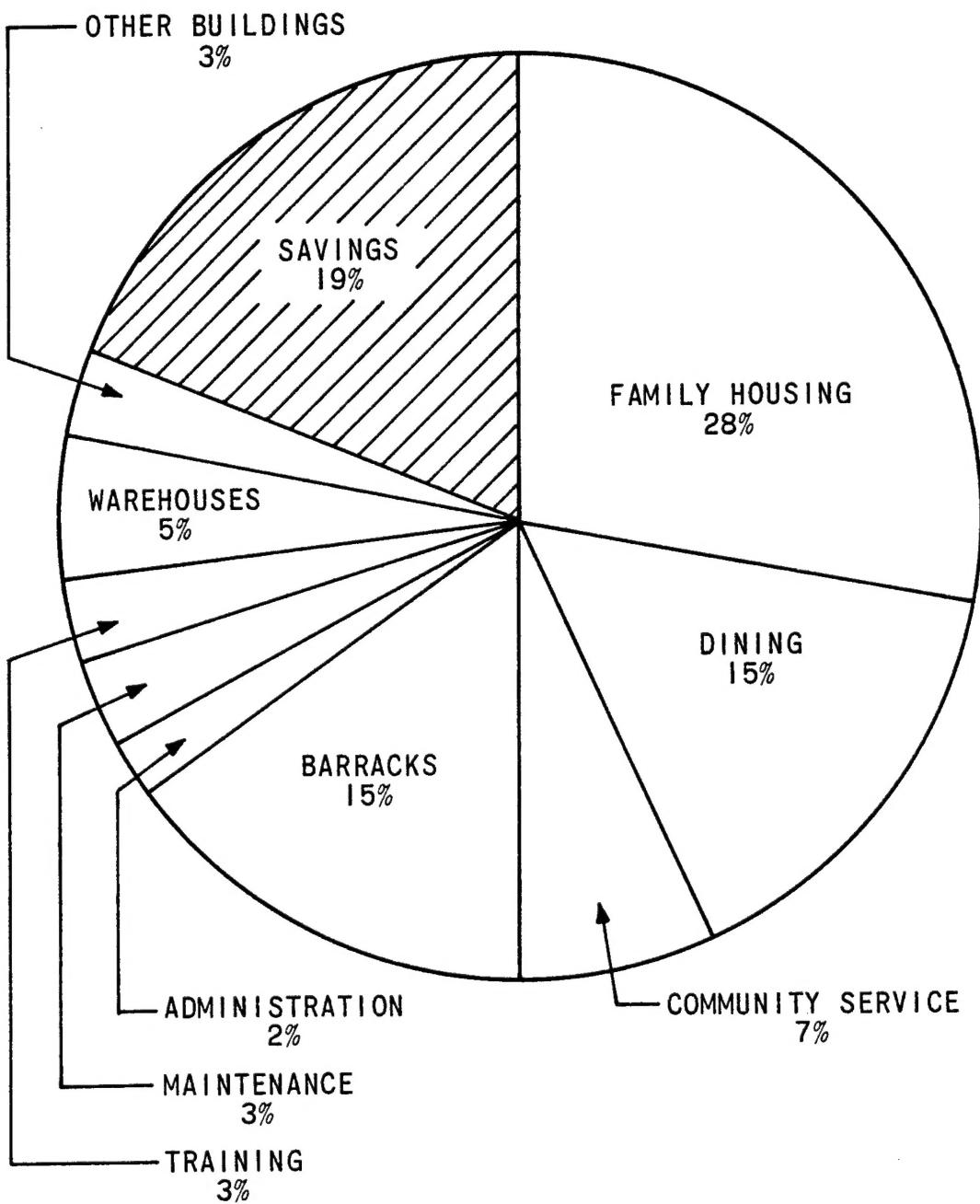


FIGURE 2
FORT KNOX
BASEWIDE SOURCE ENERGY CONSUMPTION
AFTER ENERGY CONSERVATION PROJECTS
(BASE YEAR 1975)

ALLOCATION OF ENERGY CONSERVATION
PROJECTS SAVINGS
FOR SIGNIFICANT BUILDING GROUPS

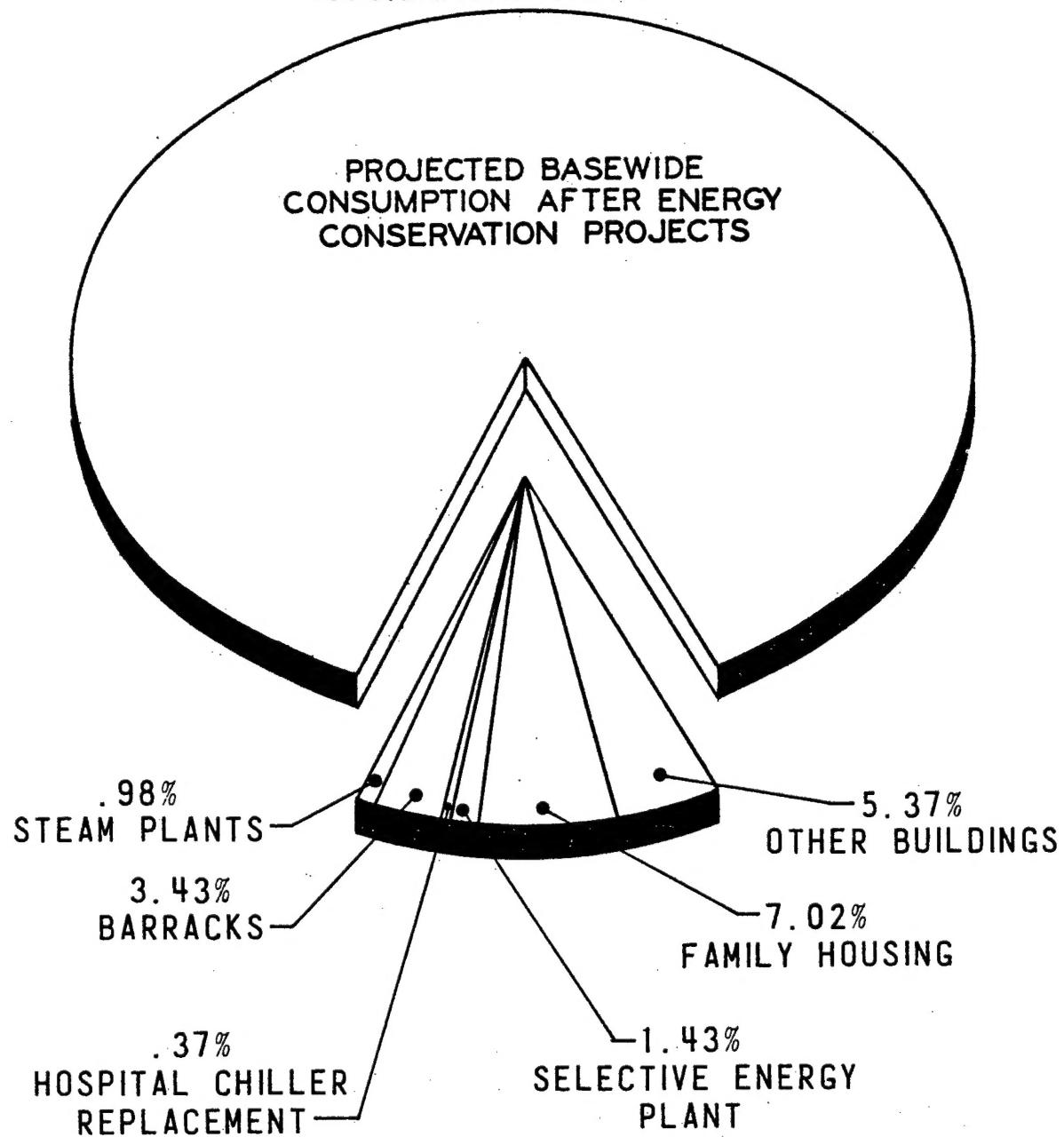


FIGURE 3

Assistance was given in evaluating the use of solid waste for reducing source energy consumption at Fort Knox. This project, recommended by others, provides for the installation of a solid waste-burning incinerator facility to supply steam to one of the existing steam distribution systems. This facility, which is presently under construction, was found to be in accordance with similar facilities recommended by us at other Mobile District COE bases.

The incorporation of a total energy system at this installation would not be recommended. However it is recommended that a selective energy plant with electric peak shaving capability be constructed. This SE plant would save 1.4 percent of source energy used while basewide reduction in natural gas and fuel oil would amount to 37 percent. The plant would also be capable of generating 38 percent of the basewide electric power requirement and would shave 58 percent of the annual electric peak. Detailed descriptions of the TE/SE systems analyzed are included in the report entitled Total Energy, Selective Energy, and Central Boiler Plants report in Volume I.

EXECUTIVE SUMMARY - INCREMENTS F AND G

This is a summary of the two phases of work, Increments F and G, that were completed in December, 1982.

The purpose of Increment F of the Basewide Energy Systems Plan is to identify and develop recommendations that can be used by Fort Knox in preparing its energy management plan. Increment G identifies maintenance, repair and minor construction projects for the purpose of conserving energy. These are energy conservation projects that did not meet ECIP criteria or did not fit the ECIP program at the time that Increments A, B, C, D and E of the study were completed.

The average costs of energy for FY 81 are given in Table 7 in the Appendix. These costs have been used as the basis for determining the dollar savings due to energy conservation.

Projects developed within the scope of Increments F and G are summarized in Tables 8 and 9 respectively (See Appendix). Projects are prioritized by their E/C ratio. The E/C ratio is defined as the ratio of yearly energy savings in million Btu to the cost estimate in thousands of dollars. Any project showing a payback of 15 years or less and a Benefit-to-Cost ratio (B/C) greater than 1.0 is recommended. Material and labor cost estimates are representative of April, 1981 prices.

Nine projects were put into 1391 format to be submitted by Fort Knox for possible ECIP funding.

Three projects conserve cold and hot water. The first, Flow Controlled Showerheads, involves replacing existing showerheads with flow controlled showerheads. The second project, Toilet Tank Dams, involves installing two inserts into the tank toilets to save approximately 2 gallons per flush without affecting head pressure or flushing action. The third project, Flush Valve Restrictors, involves installing a restrictor on toilets and urinals to save 2 gallons per flush.

The next two projects, Condenser Water Reset and Chilled Water Reset, involve resetting the condenser water downward and the chilled water upward. These projects are recommended for several buildings at Fort Knox.

Replacement of Converted Coal-Fired Boilers project involves the replacement of several small central boilers that have been converted from firing coal to natural gas and fuel oil.

The next project, Addition of Thermal Windows, recommends replacing existing double hung windows with thermal windows.

The final two projects, Install PVC Door Strips and Ceiling Fans, were combined into one 1391. The first project recommends installing PVC door strips in conjunction with garage doors to reduce infiltration when the doors are open. The second project involves the installation of ceiling fans in high ceiling areas to reduce stratification.

The ECIP documentation for these projects appears in Appendix B of Volume IV. A detailed description of these projects is contained in Volumes IV and V.

The total estimated source energy savings due to implementation of all the recommended projects in Increment F is 260,000 mega-Btu per year. The total estimated savings due to implementation of all recommended projects in Increment G is 230,000 mega-Btu per year.

CONCLUSION

The projected future energy savings at Fort Knox due to the scheduled ECIP projects developed under Increments A, B, C, D and E, construction of the Heat Recovery Incinerator Facility, Selective Energy Plant, EMCS Extension and recommended projects from Increments F and G is shown in Figure 4. Scheduled ECIP projects at Fort Knox include EMCS (MCA Project No. 297.20) and Adjust Fresh Air Quantities (MCA Project No. 325.000).

Figure 5 represents a forecast of future energy costs at Fort Knox. The graph compares how costs could escalate if no energy conservation projects are implemented versus energy costs if all cost effective projects are implemented. The energy conservation projects are assumed to be implemented in the following three phases:

- Phase I - Scheduled ECIP projects
- Phase II - Heat Recovery Incinerator Facility
- Phase III - EMCS Extension and Increments F and G projects
- Phase IV - Selective Energy Plant

Figure 5 does not account for new building construction.

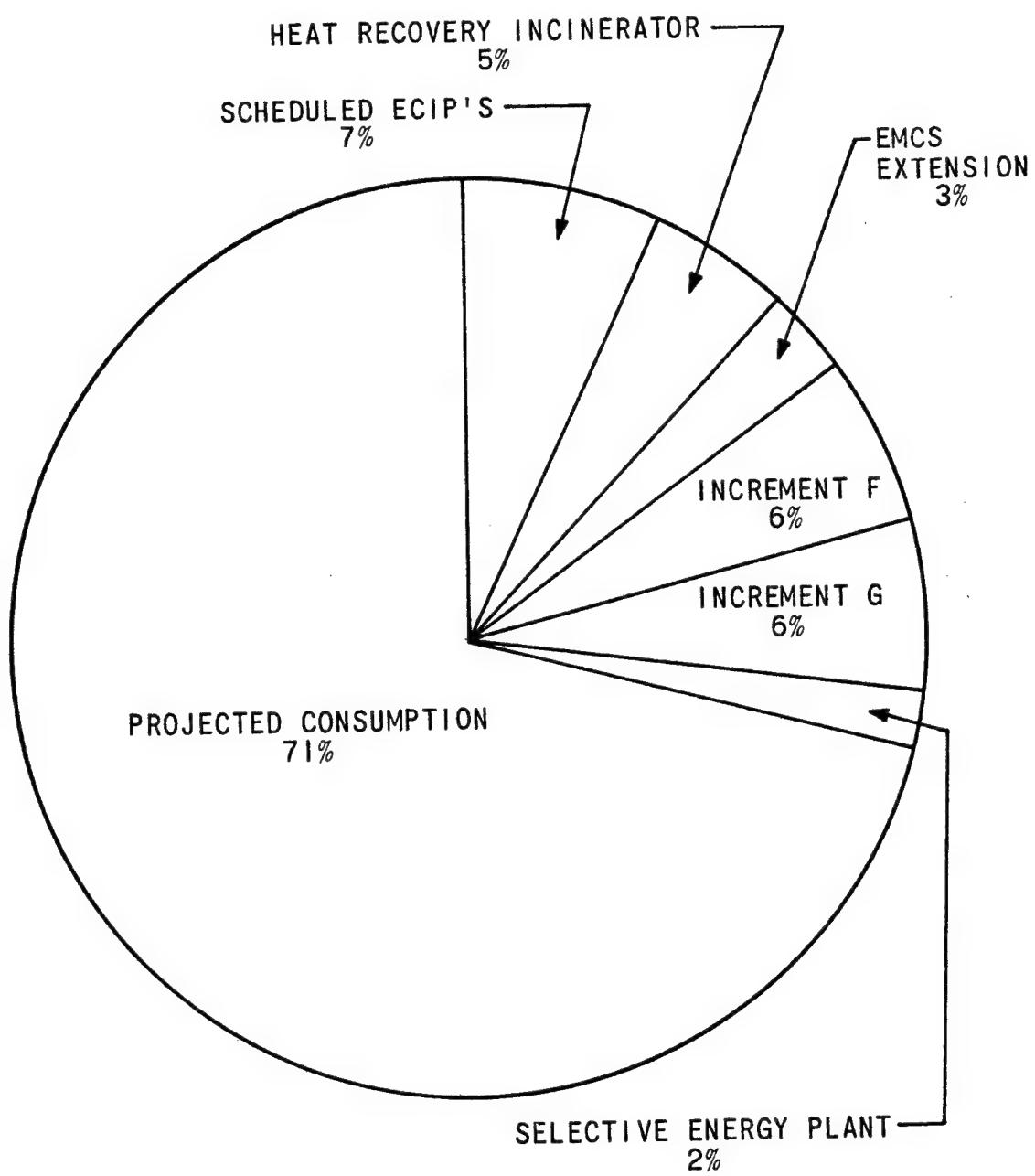
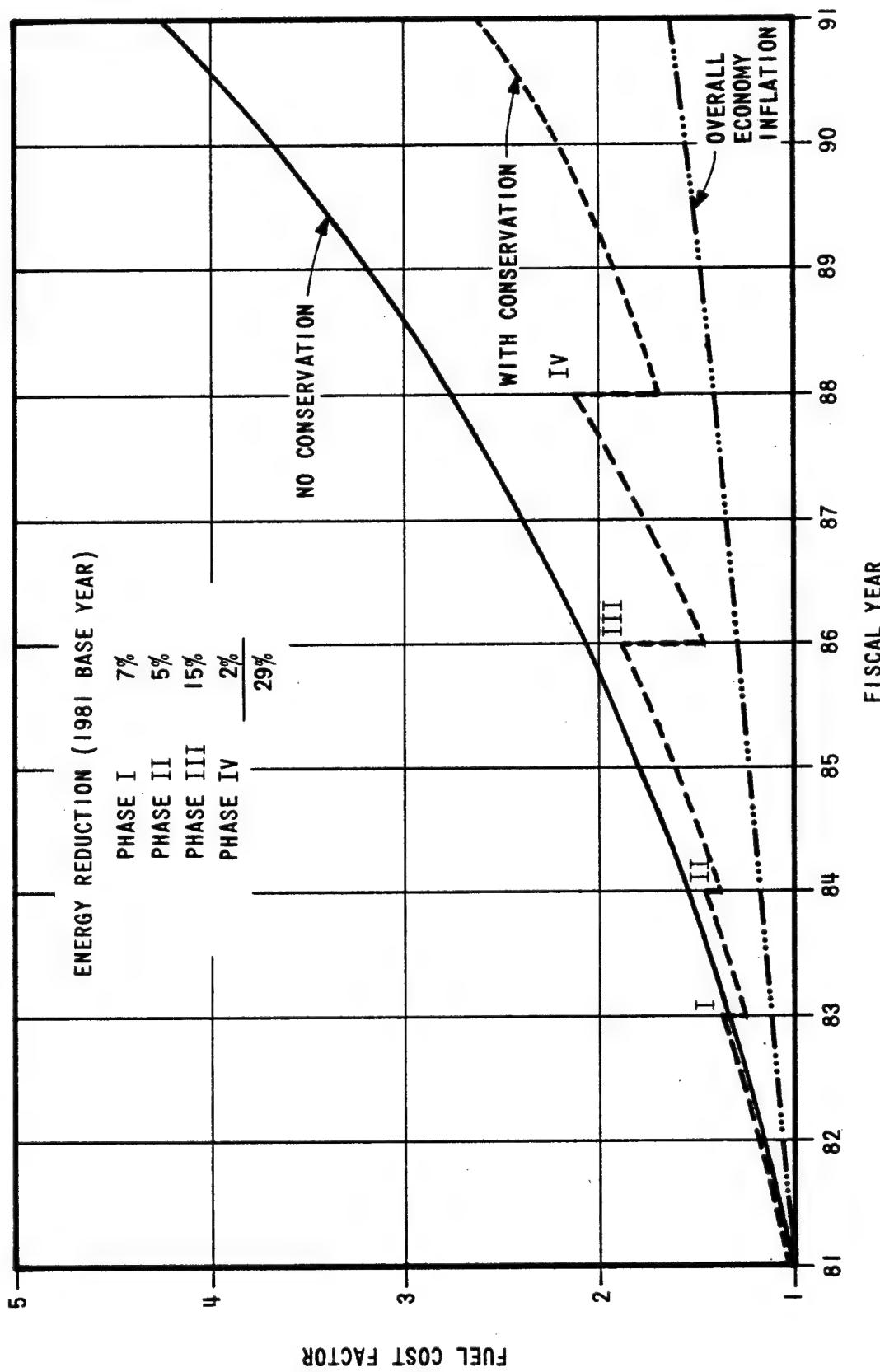


FIGURE 4
FORT KNOX
BASEWIDE SOURCE ENERGY CONSUMPTION
(BASE YEAR 1981)

FIGURE 5

EFFECT OF ESCALATION AND ENERGY
CONSERVATION ON FUEL COST

WITH CONSERVATION -----
NO CONSERVATION - - - - -
OVERALL ECONOMY INFLATION - - - - -



APPENDIX

TABLES

TABLE I
TYPICAL BUILDING CONSTRUCTION DATA
FORT KNOX

GROUP BLDG. NO.	BUILDING DESCRIPTION	CONSTRUCTION				"U" VALUES				WINDOW AREA (SF. FT. ²)	SYSTEM	CAP. (TONS)	HEATING	PEAK TONS LOAD HWH	DOMESTIC HOT WATER		
		NO. FL.S.	ROOF	MALL	FLOOR	WINDOW	DOOR	ROOF	WALL								
A-1 5932 ADMINISTRATION & STORAGE	1 BUILT-UP	BRICK ON CONC. FRAME	SLAB ON GRADE	STORM CLEAR GLASS	METAL HOLLOW CORE	.14 .18	.30 -.06	1.13 1.13	.55 .55	682 1,186	CHILLER	17	B. P. 5943	STEAM TO HW	42.0 281.5	75 GAS	
A-2 2382 COMMAND BUILDING	2 BUILT-UP	CONC. BLOCK	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL	.06 .06	.47 -.06	1.13 1.13	.55 .55	840 8405	HOME	-	R. P. 2380	STEAM TO HW	- 221.8	75 STEAM	
A-3 6715 ADMINISTRATIVE	2 SHINGLE	COMPOSITE	CLAPBOARD ON TILE, VENTED CRANL SPACE	SOLID GLASS	WOOD SOLID CORE	.05 .05	.54 1.05	1.13 1.13	.49 .47	280 5200	HOME	-	BOILER	GAS	- 251.3	30 GAS	
AH-1 5253 HANGAR	1 BUILT-UP	CONCRETE	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL	.04 .04	.58 1.06	1.13 1.13	.49 .47	2193 18905	WINDOW UNITS	2	B. P. 5213	STEAM TO HW	22.2 588.7	HOME -	
B-1 6011 BARRACKS	3 BUILT-UP	BRICK ON CONC. FRAME	SLAB ON GRADE	SINGLE CLEAR GLASS	STEEL HOLLOW CORE	.04 .04	.29 -.06	1.13 1.13	.55 .55	40650 40650	CHILLER	75	F. F. 5943	STEAM TO HW	188.6 920.0	21000 GAS	
B-2 6557 BARRACKS	3 BUILT-UP	CONC. BLOCK	TILE, VENTED CRANL SPACE	SOLID GLASS	SOLID CORE	.06 .06	.13 .06	1.13 1.13	.49 .47	5834 39874	HOME	-	BOILER	0IL	- 68.7	250 STEAM	
B-3 7306 BARRACKS	2 SHINGLE	COMPOSITE	CLAPBOARD ON WOOD FRAME	SINGLE CLEAR GLASS	SOLID CORE	.32 .32	.36 .06	1.13 1.13	.49 .47	6086 4,120	HOME	-	BOILER	GAS	- 129.4	85 GAS	
B-4 2607 BOQ	3 BUILT-UP	CONC. BLOCK	SLAB ON GRADE	SINGLE CLEAR GLASS	HOLLOW CORE	.16 .11	-.11 -.06	1.13 1.13	.55 .55	1,920 23453	THRU	40	UNIT HEATERS	ELEC	73.2 339.6	60 ELEC	
CS-1 1173 CHAPEL	1 COMPOSITE	BRICK	WOOD, ENCL. CRANL SPACE	SINGLE STAINED GLASS	SOLID CORE	.26 .26	.17 .06	1.13 1.13	.49 .47	6986 6,306	CHILLER	30	BOILER	GAS	87.4 227.7	HOME -	
CS-2 5007 CHAPEL	1 SHINGLE	COMPOSITE	CLAPBOARD ON WOOD, ENCL. CRANL SPACE	SINGLE STAINED GLASS	SOLID CORE	.34 .34	.26 .19	1.13 1.13	.49 .47	4111 3765	HOME	-	BOILER	GAS	- 171.1	40 GAS	
CS-3 4554 MUSEUM	2 BUILT-UP	CONCRETE	SLAB ON GRADE	NONE	HOLLOW CORE	.2 .2	.5 -.5	-.5 -.5	-.5 -.5	-	29131 29131	CHILLER	90	BOILER	GAS	48.3 222.7	30 GAS
CS-4 0126 CAFETERIA	1 BUILT-UP	MASONRY BLOCK	SLAB ON GRADE	SINGLE TINTED GLASS	HOLLOW CORE	.17 .17	.19 -.06	1.13 1.13	.55 .55	1,263 16200	CHILLER	275	BOILER	0IL	56.6 325.3	65 GAS	
CS-5 2320 EXCHANGE	2 SHINGLE	COMPOSITE	CONC. BLOCK	SLAB ON GRADE	SINGLE CLEAR GLASS	.056 .056	.36 -.06	1.13 1.13	.55 .55	610 7180	COND. UNIT	20	BOILER	GAS	39.1 169.8	NO GAS	
CS-6 1383 ADMINISTRATION	2 SHINGLE	COMPOSITE	CONC. BLOCK	CONC.-BASEMENT	SINGLE CLEAR GLASS	.3 .3	.5 1.06	1.13 1.13	.55 .55	621 7356	WINDOW UNITS	15	UNIT MTRS	GAS	1.4 149.2	40 GAS	
CS-7 7320 CERAMIC SHOP	1 SHINGLE	COMPOSITE	CLAPBOARD ON WOOD FRAME	SINGLE CLEAR GLASS	SOLID CORE	.30 .30	.36 -.06	1.13 1.13	.49 .47	490 7200	HOME	-	BOILER	GAS	- 270.8	30 GAS	
CS-8 1227 COMMUNICATIONS SYSTEM BLDG.	2 BUILT-UP	CONC. BLOCK	TILE, BASEMENT	SINGLE CLEAR GLASS	SOLID CORE	.15 .15	.35 .54	1.13 1.13	.49 .47	1,081 24129	CHILLER	33	BOILER	GAS	74.6 234.3	70 GAS	
CS-9 850 GYMNASIUM	1 BUILT-UP	BRICK OR STEEL FRAME	SLAB ON GRADE	SOLID GLASS	HOLLOW CORE	.12 .12	-.2 -.06	1.13 1.13	.49 .47	128 33116	HOME	-	B. F. 852	STEAM	- 1395.6	60 STEAM	
CS-11 2385 BOWLING ALLEY	1 BUILT-UP	CONC. BLOCK A BRICK	SLAB ON GRADE	NONE	METAL HOLLOW CORE	.21 .21	.32 -.06	1.13 1.13	.49 .47	22351 24129	CHILLER	55	BOILER	GAS	104.9 938.8	40 GAS	
CS-12 7060 THEATER	1 BUILT-UP	ASBESTOS BOARD	SLAB ON GRADE	SINGLE CLEAR GLASS	SOLID CORE	.2 .2	-.3 -.06	1.13 1.13	.49 .47	1,266 12691	CHILLER	13	BOILER	GAS	84.1 380.2	HOME -	
CS-13 5223 FIRE STATION	1 BUILT-UP	CONC. BLOCK A BRICK	SLAB ON GRADE	SINGLE CLEAR GLASS	HOLLOW CORE	.2 .2	-.3 -.06	1.13 1.13	.55 .55	232 4,293	HOME	-	B. P. 5213	STEAM TO HW	171.8	30 GAS	
CH-1 1198 COLD STORAGE	1 BUILT-UP	CONC. BLOCK 6 STUCCO	SLAB ON GRADE	SINGLE CLEAR GLASS	INSULATED "	.2 .2	-.3 -.06	1.13 1.13	.55 .55	72 26045	WINDOW UNITS	5	UNIT HEATERS	GAS	17.1 27.4	30 GAS	
D-1 5942 MESS HALL	1 BUILT-UP	BRICK ON CHU CRANL SPACE	SINGLE CLEAR GLASS	WOOD & STEEL	.2 .2	.3 .5	1.13 1.13	.49 .47	1,167 13280	CHILLER	75	B. P. 5943	STEAM	19.6 187.3	1,000 GAS		
D-3 6723 MESS HALL	1 SHINGLE	COMPOSITE	CLAPBOARD ON WOOD FRAME	SINGLE CLEAR GLASS	WOOD	.30 .30	.23 .06	1.13 1.13	.46 .45	416 2892	HOME	-	BOILER	GAS	148.4 148.4	86 GAS	
FH-2 432 FAMILY HOUSING	2 SLATE	BRICK	TILE, WOOD	SINGLE CLEAR GLASS	SOLID CORE	.04 .04	.32 .34	1.13 1.13	.49 .47	305 4506	*	7	BOILER	GAS	7.6 86.1	40 GAS	
FH-3 4408 FAMILY HOUSING	1 SHINGLE	COMPOSITE	BRICK	VENTED CRANL SPACE	SOLID CORE	.07 .07	.20 .06	1.13 1.13	.49 .47	304 3728	HOME	-	FURNACE	GAS	- 105.5	30 GAS	
FH-4 7843 FAMILY HOUSING	1 SHINGLE	COMPOSITE	CLAPBOARD ON WOOD FRAME	SOLID GLASS	CLEAR GLASS	.05 .22	-.2 -.06	1.13 1.13	.49 .47	304 3042	HOME	-	FURNACE	GAS	- 77.2	40 GAS	

* CALCULATIONS WERE BASED ON A PERCENTAGE OF THE GROUP HAVING AIR CONDITIONING

TABLE I (CONT'D)
TYPICAL BUILDING CONSTRUCTION DATA
FORT KNOX

GROUP NO.	BUILDING NO.	DESCRIPTION	CONSTRUCTION			'U' VALUES			WINDOW AREA (SF.)	COOLING SYSTEM CAP. (TONS)	HEATING SYSTEM CAP. FUEL (G.)	DOMESTIC HOT WATER CAP. FUEL (G.)
			FLOOR	WALL	ROOF	WINDOW	DOOR	ROOF				
PH-5	5683 FAMILY HOUSING	PITCH 4 GRAVEL	ASBESTOS & SLATE	SLAB ON BRICK	WOOD	SINGLE CLEAR GLASS	WOOD & WOOD STORM	.07	.29	-.27	1.13	.49
PH-6	5845 FAMILY HOUSING	SHINGLE	BRICK	WOOD	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.06	.17	-.07	1.13	.49
PH-7	6434 FAMILY HOUSING	COMPOSITE	BRICK	SLAB ON BRICK	WOOD	SINGLE CLEAR GLASS	WOOD	.08	.2	-.1	1.13	.49
PH-8	5307 FAMILY HOUSING	SHINGLE	BRICK & WOOD	TILE	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.14	.35	-.37	1.13	.49
PH-9	4101 FAMILY HOUSING	COMPOSITE	CLAPBOARD ON WOOD	BASMENT	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.06	.17	-.06	1.13	.49
L-1	0016 LAUNDRY	COMPOSITE	ASBESTOS ON WOOD FRAME	SLAB ON WOOD FRAME	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.08	.2	-.1	1.13	.49
LA-1	1068 ANIMAL HOLDING CENTER	BUILT-UP	CONC. BLOCK	BASEMENT	HOLLOW CORE	SINGLE CLEAR GLASS	WOOD	.08	.36	-.36	1.13	.49
H-1	2000 DENTAL CLINIC	BUILT-UP	BRICK OR CONC. BLOCK	TILE ON CONC. ENCL. CIL. SP.	SOLID CORE	SINGLE CLEAR GLASS	ALUMINUM	.11	.32	-.34	1.13	.49
H-2	680 DISPENSARY	COMPOSITE	CLAPBOARD ON WOOD FRAME	TILE	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.26	.23	-.23	1.13	.49
HA-1	2783 SMALL ARMS REPAIR	BUILT-UP	CONC. BLOCK	BASEMENT	HOLLOW CORE	SINGLE CLEAR GLASS	WOOD	.05	.32	-.34	1.13	.49
HA-2	6117 TANK MAINTENANCE	BUILT-UP	CONC. BLOCK & METAL	SLAB ON GRADE	INSULATED	SINGLE CLEAR GLASS	METAL	.27	.51	-.57	1.13	.49
HA-3	7387 MAINTENANCE	SHINGLE	CLAPBOARD ON WOOD FRAME	SLAB ON GRADE	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.08	.27	-.27	1.13	.49
S-1	5101 DATA PROCESSING	BUILT-UP	BRICK OR CONC. BLOCK	TILE	SOLID CORE	SINGLE CLEAR GLASS	METAL	.31	.23	-.24	1.13	.49
T-1	6018 CLASSROOM & HEADQUARTERS	BUILT-UP	BRICK OR CONC. BLOCK	SLAB ON GRADE	METAL	SINGLE CLEAR GLASS	WOOD	.11	.32	-.34	1.13	.49
T-2	9298 CLASSROOM	BUILT-UP	CONC. BLOCK	SLAB ON GRADE	WOOD	SINGLE CLEAR GLASS	WOOD	.05	.17	-.18	1.13	.49
T-3	1899 VEHICLE TRAINING	COMPOSITE	CLAPBOARD ON WOOD FRAME	SLAB ON GRADE	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.3	.27	-.27	1.13	.49
U-1	ALL WASTE WATER TREATMENT	WATER TREATMENT	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
U-2	4200 PUMP HOUSES	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
U-3	0017 BOILER PLANT	CORRUGATED ASBESTOS	SLAB ON STEEL FRAME	SINGLE CLEAR GLASS	METAL	1.18	1.18	-.05	1.13	-.05	1.06	1.06
U-4	CLOTHING & TEXTILE REPAIR	BUILT-UP	CONC. BLOCK	CONC. FLOOR	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.15	.53	-.53	1.13	.49
V-1	6569 WAREHOUSE	SHINGLE	CLAPBOARD ON WOOD FRAME	SLAB ON GRADE	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.26	.36	-.36	1.13	.49
V-2	2931 WAREHOUSE	BUILT-UP	CONC. BLOCK	SLAB ON GRADE	SOLID CORE	SINGLE CLEAR GLASS	WOOD	.2	.5	-.5	1.13	.49
X	NO UTILITIES	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
Z	ELECTRIC ONLY (INCLUDES ELECTRIC AUXILIARIES & OUTDOOR LIGHTING)	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE

*CALCULATIONS WERE BASED ON A PERCENTAGE OF THE GROUP HAVING AIR CONDITIONING

TABLE 2
TYPICAL BUILDING ENERGY CONSUMPTION DATA
FORT KNOX

GROUP NO.	BLDG.	BUILDING DESCRIPTION	ANNUAL ENERGY SOURCE CONSUMPTION BTUx10 ⁶			ELEC - ENER. CONSUMPTION		BTU x 10 ³ FT ²
			FUEL	ELEC.	TOTAL	KW PEAK	KWH/YR	
A-1	5932	ADMINISTRATION & STORAGE	649	671	1298	40	53170	109.4
A-2	2382	COMMAND BUILDING	434	1581	2015	32	136310	237.5
A-3	6715	ADMINISTRATIVE	546	265	811	10	22810	253.4
AH-1	5253	HANGAR	1376	422	1798	17	36386	95.1
B-1	6011	BARRACKS	5820	2853	8673	134	245947	213.4
B-2	6557	BARRACKS	4582	4430	9012	86	381870	228.3
B-3	7306	BARRACKS	926	153	1079	4	12110	228.6
B-4	2607	BOQ	0	4655	4655	260	401282	198.7
CS-1	1173	CHAPEL	342	966	1308	76	83258	204.8
CS-2	5007	CHAPEL	1106	147	1253	5	12670	332.8
CS-3	4554	MUSEUM	1488	1051	2539	125	90618	109.8
CS-4	0126	CAFETERIA	4067	6506	10573	326	560897	652.7
CS-5	2320	POST EXCHANGE	503	335	838	37	28883	116.7
CS-6	1383	POST HOUSING ADMINISTRATION	280	898	1178	15	77441	160.6
CS-7	7320	CERAMIC SHOP	930	95	1025	6	8200	142.4
CS-8	1227	COMMUNICATIONS SYSTEM BLDG.	141	20987	21128	472	1089237	875.6
CS-9	850	GYMNASIUM	5701	615	6316	22	53020	190.3
CS-11	2385	BOWLING ALLEY	1151	4112	5263	215	354497	235.5
CS-12	7060	THEATER	949	752	1701	86	64810	132.0
CS-13	5223	FIRE STATION	612	346	958	10	29800	223.2
CW-1	1198	COLD STORAGE WAREHOUSE	214	496	710	15	42780	27.3
D-1	5942	MESS HALL	11394	7801	19195	220	672480	1445.4
D-3	6723	MESS HALL	2399	126	2525	4	10830	873.1
FH-2	432	FAMILY HOUSING	175	45	220	8	3867	48.8
FH-3	4408	FAMILY HOUSING	832	89	921	6	7630	247.0
FH-4	7543	FAMILY HOUSING	542	143	685	3	12340	225.2

TABLE 2 (CONT'D)
TYPICAL BUILDING ENERGY CONSUMPTION DATA
FORT KNOX

GROUP NO.	BLDG.	BUILDING DESCRIPTION	ANNUAL ENERGY SOURCE CONSUMPTION BTUx10 ⁶			ELEC'L ENER. CONSUMPTION		BTU x 10 ³ FT ²
			FUEL	ELEC.	TOTAL	KW PEAK	KWH/YR	
FH-5	5683	FAMILY HOUSING	1003	191	1194	3	16478	382.6
FH-6	1445	FAMILY HOUSING	599	755	1354	18	65120	207.0
FH-7	4634	FAMILY HOUSING	1153	311	1464	8	26780	257.7
FH-8	5307	FAMILY HOUSING	2260	653	2913	13	56310	274.2
FH-9	4101	FAMILY HOUSING	394	71	465	11	6146	184.2
L-1	0018	LAUNDRY	27762	1495	29257	87	128880	587.2
LA-1	1068	ANIMAL HOLDING CENTER	164	611	775	24	52669	152.6
M-1	2000	DENTAL CLINIC	1186	1045	2231	85	90092	205.8
M-2	640	DISPENSARY	322	65	387	2	5570	176.2
MA-1	2783	INSTRUMENT & SMALL ARMS REPAIR	2028	2501	4529	122	215620	211.6
MA-2	6117	TANK MAINTENANCE	648	528	1176	14	45480	158.5
MA-3	7347	MAINTENANCE	332	118	450	4	10130	144.8
S-1	5101	DATA PROCESSING & CHILDCARE	2190	4855	7045	166	418500	200.4
T-1	6014	CLASSROOM & HEADQUARTERS	503	605	1108	54	52161	200.2
T-2	9298	CLASSROOM	1134	701	1836	16	60470	170.0
T-3	1543	VEHICLE TRAINING	411	104	515	5	9000	65.1
U-1	ALL OF GROUP	WASTE WATER TREATMENT	→	→	N/A	→	→	→
U-2	ALL OF GROUP	WATER TREATMENT	→	→	N/A	→	→	→
U-3	4208	PUMP HOUSES	0	9443	9443	109	814080	12540.5
U-4	0017	BOILER PLANT	32	283	315	5	24410	117.2
W-1	6569	CLOTHING & TEXTILE REPAIR	2284	2146	4430	166	185032	110.8
W-2	2931	WAREHOUSE	86	103	189	3	8920	145.8
W-3	6570	WAREHOUSE	1384	2423	3807	4.29	208870	475.9
X		NO UTILITIES	→	→	N/A	→	→	→
Z		ELECTRIC ONLY	0	70903	70903	N/A	6112310	N/A

TABLE 3
BUILDING OCCUPANCY
FORT KNOX

GROUP NO.	BLDG	BUILDING DESCRIPTION	NORMAL PEAK POPULATION	OCCUPANCY
A-1	5932	ADMINISTRATION & STORAGE	67	7:00 A.M. TO 4:30 P.M. - WEEKDAYS
A-2	2382	COMMAND BUILDING	80	6:30 A.M. TO 5:30 P.M. - WEEKDAYS
A-3	6715	ADMINISTRATIVE	6715	6:30 A.M. TO 4:30 P.M. - WEEKDAYS
AH-1	5253	HANGAR	110	OPEN 24 HOURS
B-1	6011	BARRACKS	340	OPEN 24 HOURS
B-2	6557	BARRACKS	250	OPEN 24 HOURS
B-3	7306	BARRACKS	45	OPEN 24 HOURS
B-4	2607	BOQ	45	OPEN 24 HOURS
CS-1	1173	CHAPEL	150	7:00 A.M. TO 12:00 P.M. - WEEKDAYS 7:00 A.M. TO 12:00 P.M. - SUNDAY
CS-2	5007	CHAPEL	150	8:00 A.M. TO 4:30 P.M. - WEEKDAYS 8:00 A.M. TO 12:30 P.M. - SUNDAY
CS-3	4554	MUSEUM	8	10:00 A.M. TO 4:30 P.M. - WEEKDAYS
CS-4	126	CAFETERIA	250	5:30 A.M. TO 7:30 P.M. - 7 DAYS A WEEK
CS-5	2320	POST EXCHANGE	50	7:30 A.M. TO 4:00 P.M. - WEEKDAYS
CS-6	1383	POST HOUSING ADMINISTRATION	29	7:00 A.M. TO 4:30 P.M. - WEEKDAYS
CS-7	7320	CERAMIC SHOP	8	9:00 A.M. TO 2:00 P.M. - THURSDAY
CS-8	1227	COMMUNICATIONS SYSTEM BLDG.	43	OPEN 24 HOURS
CS-9	850	GYMNASIUM	500	8:00 A.M. TO 9:00 P.M. - 7 DAYS A WEEK
CS-11	2385	BOWLING ALLEY	150	11:00 A.M. TO 11:00 P.M. - 7 DAYS A WEEK
CS-12	7060	THEATER	680	6:00 P.M. TO 11:00 P.M. - 7 DAYS A WEEK
CS-13	5223	FIRE STATION	6	OPEN 24 HOURS
CW-1	1198	COLD STORAGE WAREHOUSE	7	7:00 A.M. TO 4:00 P.M. - WEEKDAYS
D-1	5942	MESS HALL	300	4:00 A.M. TO 8:00 P.M. - 7 DAYS A WEEK
D-3	6723	MESS HALL	185	3:00 A.M. TO 8:00 P.M. - 7 DAYS A WEEK
FH-2	432	FAMILY HOUSING	4	OPEN 24 HOURS
FH-3	4408	FAMILY HOUSING	6	OPEN 24 HOURS
FH-4	7543	FAMILY HOUSING	4	OPEN 24 HOURS
FH-5	5683	FAMILY HOUSING	4	OPEN 24 HOURS
FH-6	1445	FAMILY HOUSING	8	OPEN 24 HOURS
FH-7	4634	FAMILY HOUSING	4	OPEN 24 HOURS
FH-8	5307	FAMILY HOUSING	4	OPEN 24 HOURS
FH-9	4101	FAMILY HOUSING	4	OPEN 24 HOURS
L-1	0018	LAUNDRY	70	8:00 A.M. TO 5:30 P.M. - WEEKDAYS
LAB-1	1068	ANIMAL HOLDING CENTER	6	7:00 A.M. TO 4:00 P.M. - WEEKDAYS
M-1	2000	DENTAL CLINIC	110	7:00 A.M. TO 5:00 P.M. WEEKDAYS
M-2	640	DISPENSARY	19	6:30 A.M. TO 3:00 P.M. - WEEKDAYS
MA-1	2783	INSTRUMENT & SMALL ARMS REPAIR	50	7:00 A.M. TO 4:00 P.M. - WEEKDAYS
MA-2	6117	TANK MAINTENANCE	35	7:00 A.M. TO 5:00 P.M. - WEEKDAYS

**TABLE 3 (CONT'D)
BUILDING OCCUPANCY
FORT KNOX**

TABLE 4
Building Group Source Energy Consumption

Group	Description	Group Sq. Ft.	Total Source Consumption ⁶ Btu's x 10 ⁶
A	Administrative	923,886	125,929
AH	Aircraft Hangar	138,142	13,144
B	Barracks	4,768,819	883,302
CS	Community Service	1,134,798	376,846
CW	Cold Warehouse	27,900	760
D	Dining	666,460	697,287
FH	Family Housing	6,172,958	1,639,255
L	Laundry	59,211	13,594
LA	Laboratory	204,331	29,793
M	Medical	680,555	93,452
MA	Maintenance	966,328	118,859
S	School	75,680	15,147
T	Training	985,842	112,556
U-1	Waste Water Treatment	2,889	23,780
U-2	Water Treatment	9,011	20,842
U-3	Pump Houses	5,984	75,072
U-4	Boiler and A/C Plant	50,763	2,825
W	Warehouses	843,217	199,658
X	No Utilities	497,422	
Z	Electric Only (Includes outdoor lights)	378,079	70,903
			4,513,004

TABLE 5
ENERGY CONSERVATION PROJECTS
SOURCE ENERGY SAVINGS

BUILDING TYPE	ENERGY SAVINGS BTUx1,000,000	% BASEWIDE REDUCTION FY'75	PROJECT NUMBER
FAMILY HOUSING	192,116 103,559 <hr/> 295,675	4.56 2.46 <hr/> 7.02	T-65000 T-67100
HOSPITAL CHILLER REPLACEMENT	15,439	.37	
BARRACKS	9,744 66,909 735 15,370 51,296 <hr/> 144,054	.23 1.59 .02 .37 1.22 <hr/> 3.43	T-65200 T-66900 T-68400 T-68300 T-68600
STEAM PLANTS	9,899 31,024 <hr/> 40,923	.24 .74 <hr/> .98	T-67300 T-68500
SELECTIVE ENERGY PLANT	60,000	1.43	
OTHER BUILDINGS AFFECTED BY ECIP'S	26,230 5,960 18,315 46,496 29,666 99,875 <hr/> 226,542	.62 .14 .44 1.10 .70 2.37 <hr/> 5.37	T-65200 T-65100 T-66800 T-66900 T-68400 T-68300
TOTAL	782,633	18.60	

TABLE 6

ENERGY CONSERVATION PROJECTS DEVELOPED SCHEDULE - FT. KNOX, KENTUCKY

PROJECT TITLE	PROJECT NUMBER	RECOMMENDED FISCAL YEAR	COST \$ x 1000	E/C RATIO	ENERGY SAVINGS BTUx10 ⁶	YEARS PAYBACK	B/C RATIO
STORM WINDOWS, WEATHERSTRIP DOORS, AND KITCHEN LIGHTING FIXTURE IN FAMILY HOUSING	T-65000	1980	4073	49.7	192,116	10.55	1.78
POWER FACTOR IMPROVEMENT	T-65100	1980	121	49.2	5,960	13.55	1.26
REDUCTION OF BASEWIDE FLUORESCENT LIGHTING LOAD	T-65200	1980	553	65.0	35,974	4.20	1.93
TOTAL			4747		234,050		
ADJUST FRESH AIR QUANTITIES	T-66900	1981	169	670.0	113,405	.56	33.10
FAMILY HOUSING EQUIPMENT MODIFICATIONS	T-67100	1981	1203	90.7	103,559	5.22	3.64
INSTALLATION OF CEILING FANS IN HIGH BAY AREA BUILDINGS	T-66800	1981	176	104.2	18,315	1.90	9.99
STEAM PLANT MODIFICATIONS	T-67300	1981	229	43.3	9,899	4.69	4.26
TOTAL			1777		245,178		
EMCS EXTENSION	T-68300	1982	1411	81.7	115,245	5.40	2.34
TEMPORARY BUILDINGS IMPROVEMENTS	T-68400	1982	604	50.3	30,401	8.64	2.20
CONSOLIDATION OF HEATING PLANTS, ST. JOHN TANK/MOTOR PARK	T-68500	1982	776	40.0	31,024	8.77	2.11
PERMANENT BARRACKS HEATING SYSTEM IMPROVEMENTS	T-68600	1982	2557	20.1	51,296	8.56	2.23
HOSPITAL CHILLER REPLACEMENT		1982	623	24.8	15,439	7.14	2.66
TOTAL			5971		243,405		
SELECTIVE ENERGY PLANT		1983	69230	N/A	60,000	2.3	1.08
TOTAL			69230		60,000		

TABLE 7

FY 81 Average Energy Costs

Electricity	
Demand	\$4.26/kW
kWh	\$.03/kWh
Natural Gas	\$2.86/mcf
Fuel Oil	
No. 2	\$1.37/gallon
Coal	\$38.75/ton
LP Gas	\$.66/gallon

TABLE 8
Fort Knox
Summary of Project Data
Increment F

Project	Location (s)	Energy		Payback Years	E/C	B/C	Contract Cost	In-House Cost Material	Manhours	Reference Pages	Narr. Calcs.
		Savings/Year MMBtu	Dollar Savings/Year								
Disconnect Chilled Drinking Water	Bldg. 851	305	\$1,245	.16	1,497	130	\$204	-	Electrician - 8	35	A273
Swimming Pool Cover	Bldg. 850	1,000	13,075	.07	1,055	328	948	\$948	-	32	A236
Flow Controlled Shower Heads	5,259 Units (See Appendix)	59,512	332,701	.53	349	46	170,474	52,873	Plumber/ Laborer - 2630	13	A58
Turbulators for Fire Tube Boilers	11 Buildings	21,244	110,206	.7	280	40.6	75,806	27,091	Heat Shop - 970	33	A255
Condenser Water Reset	32 Buildings	12,753	46,664	1.7	161	14.8	79,626	44,445	Plumber/ Electrician - 512	24	A166
Jacket Insulation for Water Heaters	3442 Family Housing Units	9,177	36,616	3.1	81	10.0	113,519	67,243	Laborer - 1746	23	A158
Replacement of Electric Motors with High Efficiency Motors	Bldg. 851, 852, 1205, Sewage Treatment Plants, Water Treatment Plant	9,987	41,915	2.9	77	6.53	128,988	98,180	Electrician - 1211	8	A1
Chilled Water Reset	28 Buildings	5,546	20,477	3.4	79.6	7.6	69,673	38,889	Plumber/ Electrician - 448	25	A175

TABLE 8 (Cont'd)
 Fort Knox
 Summary of Project Data
 Increment F

<u>Project</u>	<u>Location (s)</u>	<u>Energy Savings/Year MMBtu</u>	<u>Dollar Savings/Year</u>	<u>Payback Years</u>	<u>E/C</u>	<u>B/C</u>	<u>Contract Cost</u>	<u>In-House Cost Material</u>	<u>In-House Cost Manhours</u>	<u>Reference Pages</u>	<u>Narr. Calcs.</u>
Install PVC Door Strips	25 Buildings	16,831	208,086	1.2	66	7.8	255,597	141,787	Carpenter - 2464	37	A281
Flush Valve Restrictors	Post Wide	2,387	11,664	3.7	58	5.0	41,042	9,542	Plumber - 725	15	A82
Improvement of Skylights	20 Buildings	141	\$1,843	1.9	41	5.1	\$3,459	\$1,554	Laborer - 58	30	A213
Toilet Tank Dams	9,470 Units (see Appendix)	12,130	59,246	5.4	38	3.3	318,106	61,871	Plumber - 4,735	14	A66
Replacement of Converted Coal-Fired Boilers	14 Buildings	15,804	206,558	2.33	32.9	10.2	480,981	324,433	Plumber - 2142	18	A112
Addition of Thermal Windows	8 Buildings	12,357	110,409	3.6	31.0	6.5	398,429	289,767	Carpenter/ Laborer - 5,500	22	A142
Boiler Feedwater Economizer	Bldg T-17	2,468	32,257	2.7	28.7	9.4	86,012	43,189	Heat Shop - 1,235	34	A265
Addition of Attic Insulation	Post Wide (see Appendix)	47,920	191,201	8.86	28.3	3.4	1,694,892	1,129,928	Laborer - 28,076	28	A196
Drop Ceilings in High-Bay Areas	Bldg. 1784, 1810	3,520	30,025	4.4	26.4	5.7	133,472	71,155	Laborer/ Carpenter - 2450	27	A184
O ₂ Trim On Boilers	16 Buildings	19,614	256,355	3.5	21.7	6.76	902,060	322,371	Electrician - 11,413	31	A228
Variable-Speed Motor Controls	Flight Simulator Bldg.	177	1,033	8.3	21	2.6	8,554	7,895	A/C Mech. - 16	10	A27

TABLE 8 (Cont'd)
 Fort Knox
 Summary of Project Data
 Increment F

<u>Project</u>	<u>Location (s)</u>	<u>Energy Savings/Year</u>	<u>Dollar Savings/Year</u>	<u>Payback Years</u>	<u>E/C</u>	<u>B/C</u>	<u>Contract Cost</u>	<u>In-House Cost Material</u>	<u>In-House Cost Manhours</u>	<u>Reference Pages</u>	<u>Narr. Calcs.</u>
Window Insulation	10 Buildings	3,828	32,774	7.1	16.5	5.1	231,775	96,261	Carpenter - 4,024	20	A130
FM Control For Building Setback*	348 Family Housing Units	5,186	9,692	69.6	7.7	.62	674,138	674,138	-	12	A45
Coal-Fired Boiler Replacement*	4 Buildings	1,050	-2,052	-73.9	6.9	-.76	151,556	123,127	Heat Shop - 416	19	A121
Replacement of Incandescent Lighting*	10 Buildings	1,402	\$8,622	23.9	6.8	.89	\$206,155	\$157,460	Electrician - 1,164	11	A36
Variable Air Volume**	None	-	-	-	-	-	-	-	-	16	A96
Boiler Plant Water Treatment With Magnets*	None	-	-	-	-	-	-	-	-	17	A97
Waste Heat Recovery From Computers*	None	-	-	-	-	-	-	-	-	29	A211
Heat Recovery Wheels, Mess Halls*	4 Buildings	-	-	-	-	-	-	-	-	36	A280

*Not recommended, or abandoned.

TABLE 9
Fort Knox
Summary of Project Data
Increment G

<u>Project</u>	<u>Location(s)</u>	<u>Energy Savings/Year</u>	<u>Dollar Savings/Year</u>	<u>Payback Years</u>	<u>E/C</u>	<u>B/C</u>	<u>Contract Cost</u>	<u>Material</u>	<u>In-House Cost</u>	<u>Manhours</u>	<u>Reference Pages</u>	<u>Narr. Calcs.</u>
Correction of Heat Recovery Wheel Operation	Building 851	2,421	31,642	.0016	48,198	14,985	50	-	A/C Mech. 2	14	B97	
Reduction of Hot Water Temperatures	21 Buildings	3,943	51,548	.02	4,341	1,350	908	-	Plumber 22	20	B138	
Filter Maintenance	5 Buildings	92.1	267	.15	1,930	138	-	17.55	Laborer 1.5	18	B123	
Ceiling Fans	32 Buildings	116,517	1,104,732	.07	1,455	360	80,065	25,850	Electrician 2806	24	B198	
Repair of Existing Time Clocks	19 Buildings	1,254	15,890	.13	618	187	2,028	373	Laborer/ Electrician 38	5	B1	
Insulation for Hot Water Storage Tanks	11 Buildings 7 Swimming Pools	679	8,875	.18	415	129	1,241	578	Laborer 36	21	B148	
Repair of Existing Boiler Economizer	Buildings 852 1731, 2780	9,200	120,244	.23	326	101	28,231	12,303	Plumber 100	16	B113	
Pipe Insulation	23 Buildings	37,850	48,208	.30	285	86.5	13,300	6,650	Laborer 250	22	B155	
Reduction of Ventilation Air Quantities	2 Buildings	97.9	646	0.6	274	41.4	358	193	A/C Mech. 4	13	B87	
Weatherstripping of Doors and Entrances	Post Wide	23,093	273,744	0.6	147	41.4	156,715	63,403	Laborer/ Carpenter 3,530	11	B71	
Repair of Insulation on Boilers	11 Buildings	369	4,823	.70	110	34.2	3,355	2,542	Plumber 32	19	B132	

TABLE 9 (Cont'd)
 Fort Knox
 Summary of Project Data
 Increment G

<u>Project</u>	<u>Location(s)</u>	<u>Energy Savings/Year</u>	<u>Dollar Savings/Year</u>	<u>Payback Years</u>	<u>E/C</u>	<u>B/C Cost</u>	<u>Contract Material</u>	<u>In-House Cost Manhours</u>	<u>Plumber/Laborer</u>	<u>Reference Pages</u>	<u>Marr. Calcs.</u>
Improvement or Replacement of Current Heating Controls	40 Buildings	25,719	329,546	.73	107	34	241,063	129,864	Laborer 2,700	6	B11
Cooling Water Treatment	5 Buildings	1,295	869	44.3	33.6	1.61	38,544	15,966	Plumber 480	10	B36
Automatic Chiller Condenser Tube Cleaning	5 Buildings	1,942	14,271	7.8	17	1.9	111,537	63,735	A/C Mech. 1,160	8	B25
Infrared Heating	32 Buildings	5,914	70,153	10.6	7.9	2.3	745,834	372,917	Heat Shop 19,555	23	B165